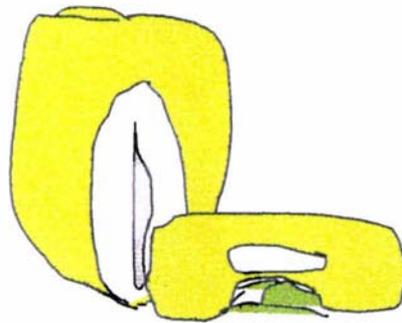


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Physical changes in maize (*Zea mays* L.) grains during postharvest drying



A thesis presented in partial fulfillment
of the requirements for the degree of

Doctor of Philosophy in

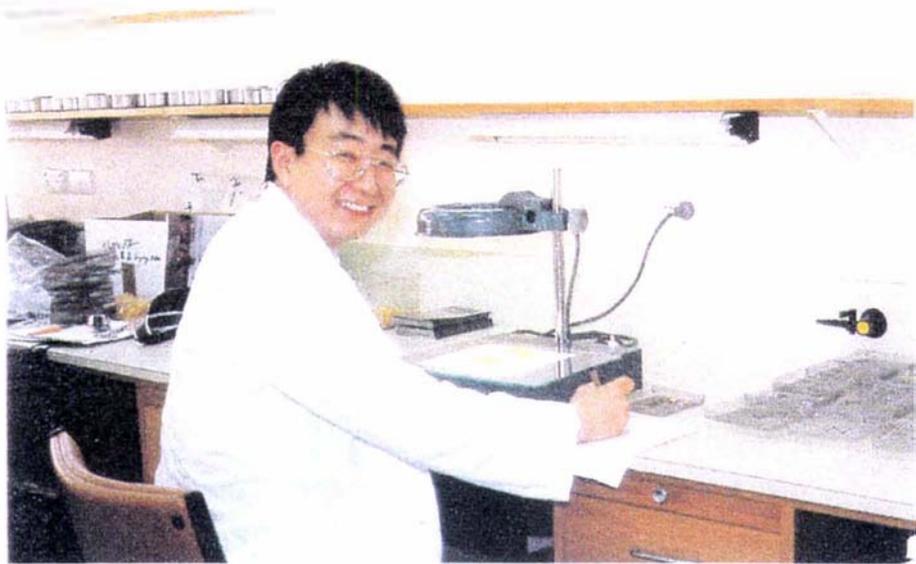
Seed Technology

at

Massey University

Tae Hoon Kim

2000



**This thesis is dedicated to the four most inspirational people in my life,
my father, Kim In Goo,
my mother, Kwon Young Wha,
grandmother, Jung Bong Hee,
and my lovely wife, Kim Hyun Ok and
to the unforgettable memories in
New Zealand...**

ABSTRACT

Stress cracking due to high temperature drying has been of concern to the maize industry because it can lead to increases in broken grain and fine material during subsequent handling. In this study, several factors affecting physical characteristics of maize grain, particularly those related to stress cracking, were investigated.

In the first year (1995-1996), the effects of several preharvest factors; hybrid, nitrogen, harvest grain moisture content, and postharvest drying factors including drying temperature and relative cooling rate on physical attributes and stress cracking in grain were investigated. Grain hardness (hard to soft endosperm ratio (H/S ratio)) was significantly affected by the interaction between hybrid and nitrogen. The effect of drying temperature and harvest moisture on drying time was dominant, while drying rate was significantly affected by hybrid and drying temperature. The effect of cooling rate on stress cracking and stress crack index (SCI) stood out among the main effects. At the lowest cooling rate of $0.23 \text{ (}^{\circ}\text{C/}^{\circ}\text{C/min.)}\bullet 10^{-2}$, checked stress cracking (checking) was minimal, and SCI was less than 100. However, at higher cooling rates from 0.55 to $1.11 \text{ (}^{\circ}\text{C/}^{\circ}\text{C/min.)}\bullet 10^{-2}$, grains had more than 25% multiple stress cracking, regardless of the levels of hybrid, nitrogen, harvest moisture and drying temperature. The predicted SCI for the three hybrids reached a maximum around at $0.75 \text{ (}^{\circ}\text{C/}^{\circ}\text{C/min.)}\bullet 10^{-2}$ cooling rate, irrespective of levels of nitrogen and drying temperature.

In the second experiment (1996-1997), the effects of grain hardness and morphological factors (grain size and shape) at a single grain drying rate and the development stress cracking over time were investigated. The re-parameterized Morgan-Mercer-Flodin (MMF) model successfully predicted the increasing rate (κ) and the maximum value (α) of percentage checking in various sizes, shapes and hardness of grains time after drying. From the data analysis, the maximum value of checking (α) showed a significant correlation with grain length ($r = -0.707$), thickness ($r = 0.620$), roundness ($r = 0.703$) and the shortest diffusion pathway (SDP; $r = 0.627$). While, the increasing rate (κ) of percentage checking with time after drying was significantly correlated with

grain bulk density ($r = -0.564$), hardness ratio ($r = -0.611$) and drying rate ($r = 0.551$), and to a lesser extent ($r > 0.35$), with the grain size parameters including hundred-grain weight, grain length, and width. Based on this result, it was suggested that removing small and rounded grains could reduce checked stress cracking by up to 40 to 50% in some dent maize hybrids. In addition, the standardized multiple regression for single grain drying rate according to H/S ratio and grain weight accounted for from 65 to 74% of the variation. Tempering grain at high temperatures reduced stress-cracked grains significantly. However, the effect of tempering on stress cracking in the hard grain hybrid was small.

In the 1997-1998 experiment, a breakage tester (HT-I drop tester) was developed and single grain breakage at various grain temperatures and times after drying was determined. Both hard and soft maize hybrids had minimal breakage at high grain temperatures (78 to 110°C), while decreasing grain temperature increased breakage exponentially. This indicated that grain temperature should be considered as a co-factor for measuring grain breakage. After drying at both 60°C and 120°C, the percentage breakage measured at ambient temperature increased rapidly during cooling in air at an ambient temperature of 20°C and a relative humidity around 65-70%. Breakage reached a maximum after about 10 minutes from the start of cooling. A Mitscherlich function was used to describe the chronological development of percent grain breakage and the analysis of the function parameters for the extent (maximum) and rate of breakage indicated that there was a significant interaction between hybrid and drying temperature for the development of grain breakage after drying.

In conclusion, the MMF and Mitscherlich models described stress cracking and grain breakage during drying and cooling of maize grain. These studies provide valuable information to grain industries to assist with minimizing grain damage during drying.

Key words: maize, quality, stress cracking, breakage susceptibility, viscoelastic, hardness, postharvest drying, cooling, tempering, nitrogen, hybrid, harvest moisture, size and shape, breakage tester.

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TABLE OF CONTENTS

ABSTRACT	iii
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	vii
LIST OF TABLES	xii
LIST OF FIGURES	xv
LIST OF PLATES	xviii

CHAPTER 1: General introduction

1-1. Introduction and background of research	1
1-2. Objectives of this thesis	2

CHAPTER 2: Literature review – Agronomic and postharvest drying factors affecting physical properties and stress cracking in maize grain

2-1. Introduction – background, scope, and the objectives of this review	3
2-1-1. Background – trends in maize use and quality traits for end users	3
2-1-2. Scope – quality maintenance and importance of drying	4
2-1-3. Scope and objectives of this review	5
2-2. Terminology	6
2-2-1. Structure of maize grain	6
2-2-2. Varieties of maize and their use	11
2-3. Maize milling industries and the maize quality attributes desired	16
2-3-1. Maize milling industries – processing procedure and products	16
2-3-2. Maize quality attributes desired for milling industries	18

2-4. Measurement of maize grain quality	27
2-4-1. Importance of grain standards and quality measurement in marketing	27
2-4-2. Measurement techniques for maize grain quality	33
2-5. Maintenance of maize grain quality	45
2-5-1. Agronomic factors affecting maize grain quality	45
2-5-2. Postharvest drying and maize quality	52
2-6. Summary and conclusions	68
 CHAPTER 3: Effects of pre-harvest and postharvest factors on grain quality attributes, drying characteristics, and stress cracking in three maize hybrids	
3-1. Introduction	72
3-2. Material and methods	74
3-2-1. Plant material	74
3-2-2. Field trial design and cropping management	74
3-2-3. Postharvest maize drying and cooling procedure	77
3-2-4. Laboratory measurements	82
3-2-5. Calculation of drying rate and cooling rate	88
3-2-6. Data analysis	91
3-3. Results	92
3-3-1. The effect of nitrogen, hybrid and harvest moisture on grain yield and quality	92
3-3-2. Drying and cooling performance	96
3-3-3. Stress cracking	102
3-4. Discussion	109
3-5. Conclusions	112

CHAPTER 4: Effects of grain size, shape, and hardness on drying rate and the occurrence of stress cracks

4-1. Introduction	114
4-2. Material and Methods	116
4-2-1. Maize hybrids and grain classification	116
4-2-2. Physical characteristics of maize grain	118
4-2-3. Stress cracking assessment	122
4-2-4. Individual grain drying rate and hardness ratio (1997)	123
4-2-5. Effects of tempering on stress cracking (1998)	124
4-2-6. Data analysis and modeling	126
4-3. Results	128
4-3-1. Stress cracking development	128
4-3-2. Relationship between single grain drying rate, grain weight and hardness ratio	139
4-3-3. The effect of tempering on stress crack reduction in maize grain	140
4-4. Discussion	142
4-5. Conclusions	146

CHAPTER 5: Development of a grain breakage susceptibility tester and a study of the effects of maize grain temperature on breakage susceptibility

5-1. Introduction	147
5-2. Material and Methods	149
5-2-1. Development of the HT-I drop tester	149
5-2-2. Maize hybrids and physical characteristics of maize grain	152
5-2-3. Experimental procedures for the grain breakage test	152
5-2-4. Data analysis and modeling	155

5-3. Results	156
5-3-1. Changes of grain temperature during drying and cooling	156
5-3-2. Breakage of maize grain at various grain temperatures	158
5-3-3. The effect of drying air temperature on grain breakage after cooling	160
5-3-4. Breakage of maize grain at various times after drying	162
5-3-5. Shrinkage of maize grain after drying at six temperatures	165
5-4. Discussion	168
5-5. Conclusions	171
CHAPTER 6: General discussion and conclusions	
6-1. Factors affecting stress cracking in maize grain	172
6-1-1. Agronomic factors	172
6-1-2. Postharvest drying factors	174
6-2. Prediction models for stress cracking and grain breakage	177
6-3. Final conclusions	178
6-4. Recommendations for future studies	179
References	181

Appendices:

Appendix 1:	Harvesting time and harvest moisture content (wet weight basis) of maize grain in the 1995-96 cropping season	207
Appendix 2:	Interactions of harvest moisture content, bulk density, and hundred-grain weight with grain size and shape and hybrid	208
Appendix 3:	Interactions of grain dimension (length (L_a), width (L_b), and thickness (L_c)) and roundness (sphericity) with grain size and shape and hybrid	209
Appendix 4:	Interactions of drying rate, hardness ratio and shortest diffusion pathway (SDP) of maize grain with grain size and shape and hybrid	210
Appendix 5:	Hand drawings of development of stress cracking in maize grains after drying at 60°C and cooling for 72 hours at ambient temperature	211
Appendix 6:	The proportion of each category of grain as determined by the position on the maize cobs	215
Appendix 7:	Detailed structure of each part of the HT-I drop tester	216
Appendix 8:	Pre-testing results and feasibility of using the HT-I drop tester	217

LIST OF TABLES

Table 2-1. The desired maize quality attributes for milling industries	26
Table 2-2. Grading standards for maize grain in the US	29
Table 2-3. Argentine grading standards for maize	32
Table 2-4. South Africa grading standards for yellow maize	33
Table 2-5. Summary of techniques for measuring mechanical properties of maize grains	39
Table 2-6. Effect of drying method on stress cracking and breakage susceptibility of dried maize grain	56
Table 2-7. Grain temperature, moisture content, and breakage susceptibility at different locations in the grain column of a cross-flow dryer after drying maize grain without cooling from 25.5% moisture to an average of 19% at 110°C	59
Table 2-8. The average effect of conventional high-temperature dryer type on the drying-air temperature, the maximum grain temperature, the percentage of stress-cracked grains and the breakage of maize grain	59
Table 2-9. Summary of maize grain drying methods	61
Table 2-10. The effect of genotype difference on drying rate and breakage susceptibility of maize grain dried at various drying air temperatures	65
Table 2-11. Physical quality characteristics of maize grain and its end use	71
Table 3-1. The effect of nitrogen, hybrid and harvest moisture on number of grains per maize cob, hundred grain weight, grain yield and bulk density	92
Table 3-2. The effect of hybrid and nitrogen on grain dimension, roundness, and hardness (hard to soft endosperm ratio)	94
Table 3-3. The effect of hybrid, nitrogen, harvest moisture, and drying temperature on drying time and drying rate of maize grain	97
Table 3-4. Average grain-surface temperature at the terminal stage of drying at various drying air temperatures	101

Table 3-5. Relative cooling rate (CR) in the slow and fast cooling systems at various cooling temperatures	102
Table 3-6. The effects of hybrid, nitrogen, harvest moisture, drying temperature, and cooling rate on the percentage of various types of stress cracking and the stress crack index (SCI) in maize grain	103
Table 4-1. Classification on size and shape of maize grains from four hybrids (before drying)	117
Table 4-2. Physical characteristics of different size and shaped grains for four maize hybrids	119
Table 4-3. Comparison of grain moisture content, hundred-grain weight, bulk density, hardness ratio, grain dimension and roundness of medium flat grains of P3902 and Clint (1998)	122
Table 4-4. The effects of hybrids and shape and size of maize grains on stress crack percentage and stress crack index (SCI) after drying at 60°C and cooling for 72 hours at ambient temperature	129
Table 4-5. Comparison of the parameters, α , κ , and δ for the MMF model for checked stress cracking in various grain size and shape categories for four hybrids	133
Table 4-6. Correlations between grain physical characteristics and the MMF model parameters	134
Table 4-7. The percentage of stress cracking and SCI of two maize hybrids after drying at 60°C and 120°C and cooling at ambient temperature (20±1°C, 65 to 70% RH) in a single layer (1998 experiment)	136
Table 4-8. Comparison of the parameters, α , κ , and δ for the MMF model for checked stress cracking in maize grain for two hybrids	138
Table 4-9. Single grain drying rate as a function of grain weight and hardness ratio	139
Table 4-10. The effect of post-drying treatments (tempering) on percentage stress cracking in various maize hybrids drying at 60 and 120°C	140
Table 5-1. Grain temperatures at the time of breakage testing of two maize hybrids dried at various drying air temperatures	157
Table 5-2. Comparison of the parameters A_{bk} (maximum) and b (rate) for breakage susceptibility of maize grain of two maize hybrids as a function of grain temperature (GT) at the time of testing	160

Table 5-3. Comparison of the percentage breakage of two maize hybrids after drying at six temperatures and cooling at ambient temperature in a single layer for 72 hours	161
Table 5-4. Comparison of the Mitscherlich function parameters for percentage breakage of maize grain during cooling at ambient temperature ($20\pm 1^{\circ}\text{C}$ and 65-70% RH) after drying at 60 and 120°C	164
Table 5-5. Difference in percentage shrinkage between Clint and P3902 at different drying air temperatures	167

LIST OF FIGURES

Figure 2-1. Longitudinal and cross sections of a maize grain enlarged approximately 30 times	7
Figure 2-2. Scanning electron micrographs of maize grain endosperm	10
Figure 2-3. Various types of maize grains	12
Figure 2-4. A triad among the components of the interdependent grain system	27
Figure 2-5. Energy requirements for production of maize in the Midwestern United States as a percentage of the total	53
Figure 2-6. Schematics of the four major types of high temperature grain dryers: cross-flow, concurrent-flow, mixed-flow or counter-flow	58
Figure 2-7. A schematic of stress cracks in maize grain	66
Figure 2-8. Maintenance of maize quality for human consumption	69
Figure 3-1. The layout of field trial in the 1995/96 season	75
Figure 3-2. The drying and cooling procedure for the 1996 drying experiment	78
Figure 3-3. Measurement of maize grain dimension (a: Length, b: Width, c: Thickness)	85
Figure 3-4. Sectioning of maize grain for measuring the ratio of hard to soft endosperm, where L_a , L_b , L_c , and L_d was defined as total-sectioned width and length, and width and length of soft endosperm area, respectively	86
Figure 3-5. A sketch of various types of stress cracks in maize grain	87
Figure 3-6. An example of calculating drying time and drying rate from the drying curve, where MC_{15} , and MC_{20} indicate the grain moisture content at 15% and 20%, and t_{15} and t_{20} indicate the time taken to reach these moisture contents	88
Figure 3-7. Average curves during cooling at various cooling temperatures (5, 25, and 45°C) and for the two different cooling systems (5, 25, and 45°C) and for the two different cooling systems (fast (=open) and slow (=closed)) at each cooling temperature, Plate 3-4)	89

Figure 3-8. The interaction between hybrid (HYB) and harvest moisture (HMC) for the number of grains per cob (NOG) (A) and between hybrid (HYB) and nitrogen (N) for the hundred-grain weight (HGW) (B)	93
Figure 3-9. The interaction between hybrid and nitrogen for maize grain hardness (Hard/Soft ratio)	95
Figure 3-10. The interactions of harvest moisture and drying temperature (a), hybrid and drying temperature (b), and drying temperature, harvest moisture and hybrid (c) for drying time of maize grain	98
Figure 3-11. The interactions of nitrogen and drying temperature (a) and drying temperature, nitrogen and harvest moisture (b) for drying time of maize grain	99
Figure 3-12. Two-way interactions among hybrids, nitrogen, harvest moisture, drying temperature, and cooling rate for stress crack index (SCI)	105
Figure 3-13. Three-way interactions among hybrid, harvest moisture, drying temperature, and cooling rate for stress crack index (SCI)	106
Figure 3-14. Models for stress crack index for three maize hybrids grown at different levels of applied nitrogen, dried at various drying temperatures and cooled at various cooling rates	108
Figure 4-1. Sectioning of maize grain for measuring the shortest diffusion pathway (SDP), W_m is defined as the minimum width across the sectioned area	118
Figure 4-2. Procedure for tempering treatments	125
Figure 4-3. The effect of interaction between hybrids and grain size and shape on stress cracking and SCI 72 hours after drying	130
Figure 4-4. Development of stress cracking in various maize grain size and shape categories for four hybrids after drying at 60°C and cooling at ambient temperature for 72 hours	131
Figure 4-5. The interaction between hybrid and drying temperature for stress cracking in maize grain	136
Figure 4-6. Development of checked stress cracking in maize grain after drying at 60°C and 120°C and cooling at ambient temperature for 72 hours (the percentage checked stress cracking data were fitted to MMF model)	138

Figure 4-7. The interaction between hybrid (HYB) and post-drying treatments (tempering) for stress cracking in maize grain	141
Figure 4-8. Stress cracking and drying rate of maize grain in relation to grain size/shape and the effect of post-drying treatments (dryeration (i.e., tempering)) on reduction of stress cracking	143
Figure 5-1. Diagram of HT-I drop tester and materials used. 1=Aluminium steel bar (201.0g) 2=Steel tube 3=Pin 4=Base 5=Maize grain 6=Stand	150
Figure 5-2. Changes in grain temperature of the two maize hybrids during drying (at 120°C) and cooling (ambient temperature; 20 ± 1°C, 65-70% RH)	157
Figure 5-3. The relationship between breakage susceptibility and grain temperature	158
Figure 5-4. The interaction between hybrid and drying temperature for percentage grain breakage (after cooling at ambient temperature for 72 hours)	161
Figure 5-5. The change in maize grain breakage during cooling at ambient temperature (20±1°C and 65-70% RH) after drying at 60 and 120°C	162
Figure 5-6. Comparison of the percentage shrinkage in grain dimension of two maize hybrids dried at various drying air-temperatures	166
Figure 5-7. A schematic diagram for maize grain dimension shrinkage phenomena after high temperature drying and fast cooling	170
Figure 6-1. A possible mechanism of stress cracking in maize grain after high temperature drying	175
Figure 6-2. The effect of tempering temperature on stress cracking and breakage susceptibility in maize grain	176

LIST OF PLATES

Plate 3-1. Hand shelling of maize grain after harvest from the field. Very small grains which passed through 6.75 mm-hole sieve were removed	79
Plate 3-2. Storage of hand-shelled grains before drying. Grains were placed into a plastic bin, tightly sealed with plastic bags, and stored at 5°C for 24 to 48 hours before drying at various drying air temperatures	79
Plate 3-3. Arrangement of maize grains in a single layer in the drying trays before drying	80
Plate 3-4. An example of measuring an instant grain surface temperature by using an infrared thermometer (The infrared thermometer in this photo indicates a surface grain temperature of 23.1°C, the air temperature was 25°C)	80
Plate 3-5. Grain cooling systems for A: fast cooling (left); grains were uncovered during cooling, and B: slow cooling (right); grains covered tightly by a tightly sealed polystyrene cover. Grain temperature was measured via an inserted thermometer in each grain lot	81
Plate 5-1. HT-I drop tester	151
Plate 5-2. Positioning the base plate before breakage testing using the HT-I drop tester. The base plate is inserted at the end of the metal tube (A) and turned 90° so that the entire sample can be recovered after impact (B)	151
Plate 5-3. Positioning the five maize grains on the base plates before drying. An extra grain was used for measuring grain temperature during drying and cooling	153
Plate 5-4. Squirrel data logger for measuring grain, oven, and ambient temperature during testing	153
Plate 5-5. Oven, HT-I drop tester and squirrel logger (Grant 12-bit) for measuring grain breakage and temperature; oven, and ambient temperature were also measured during testing	154
Plate 5-6. Grain breakage at various grain temperatures	159
Plate 5-7. Grain breakage with time after drying at 60 and 120°C at ambient temperature (20±1°C, 65 to 70% RH) cooling	163